POLYBIO Multibiometrics Database: Contents, description and interfacing platform

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Abstract. Biometrics is an automated authentication mechanism that allows the identification or verification of individual based on unique physiological and behavioural characteristics. The combination of two or more biometric technologies in one application, better known as a multimodal biometric system, can provide enhanced security. Apart from the sound choice of fusion methodologies for the combination of single modality biometrics, the success of such multimodal biometric systems significantly relies on the availability of biometric databases, through which the validation of these systems is made possible. This paper presents a new multimodal database, acquired in the framework of the POLYBIO project funded by the Cyprus Research Promotion Foundation (CRPF). The database consists of fingerprint images captured via an optical sensor, frontal and side views of still and video face images as well as the outside surface of the human palm from two web-camera sensors, and a series of voice utterances recorded with the use of a distant array microphone. The POLYBIO database includes real multimodal and multi-biometric data from 45 individuals acquired in just a single session. In this contribution, the novel platform for data acquisition and combination - through an integrated device - of the four aforementioned single biometric modalities is described and the protocols used for this purpose as well as the contents of the database and its statistics are presented.

1 Introduction

In recent years, there has been a growth in the research of biometric systems, mainly due to the increasing pressure exerted on many Western countries to increase their counter terrorism measures and legislation. Such systems can alleviate problems that plague traditional verification methods such as passwords or identification cards [1] and can be widely used for either access to physical locations such as airports and commercial buildings or for accessing remotely sensitive in-

formation via the World Wide Web. Furthermore, the use and combination of more that one modality can offer enhanced security and can exploit to a higher degree the uniqueness, universality, permanence – to a certain extend - and collectability of each of the single combined biometrics.
Although many biometric databases of single biometric traits such as fingerprint, face and voice have been developed that enabled the growth of unimodal biometric systems [2], the progress on multimodal systems is still prohibited due to the lack of reliable multi-biometric databases. The few publicly available multimodal databases consist of only matching scores produced by several biometric systems operating on different modalities [3]. Therefore, although these databases encourage the research on multimodal fusion, they do not allow further research on different types of fusion other than the scores matching of different systems. Moreover, the absence of more than two or three important traits of the same individual in a single database is another limitation of the existing multimodal biometric databases.

The creation of multimodal databases implies a certain degree of difficulty and challenges in the following manner: the design of an integrated platform for multimodal biometric data acquisition is a complex multidisciplinary approach since it combines many different methodologies for the extraction of biometric traits to be performed under a unified framework. Moreover, the procedure of data collection is highly resource- and time- consuming as it requires a significant number of test subjects that need to cooperate for the collection of their biometric traits, a process that requires a long period of time. Last but not least, the legal issues concerning the collection of biometric data are to be taken into serious consideration as this subject is highly controversial [2]. However, due to the integrated efforts of all participants involved in the POLYBIO project, most of the aforementioned difficulties have been overcome. The presented multimodal database includes fingerprint, palm, voice and still and video face images from a significant number of individuals that have been collected through a novel integrated platform. The reasons behind the selection of these specific biometric traits in the current contribution was the creation of a multimodal , multi-biometric system that offers reliable results that can be interpreted and applied in real time without increasing the user annoyance (e.g. iris scan) [4]. Increased user annoyance has been observed over the use of fingerprints mainly due to its association with criminal prosecution but this limitation has been overcome due to the increasing and popular use of systems based on fingerprint recognition for granting access to personal computer and laptops. In the sections that follow, the methodology for data collection as well as the platform for data acquisition are described and the contents of the resulting database and their statistics are presented.

2 Multibiometric Data Acquisition

The multibiometric data were collected through the use of an integrated platform that was created in the framework of project POLYBIO [5]. The scenario in the acquisition process was an office room where the acquisition hardware and software could be operated by a system supervisor, guiding the steps of the test subjects through the data collection procedure. Environmental conditions such as lighting or background noise were not controlled so as to simulate a realistic situation. The data acquisition system is depicted in Fig1 and is composed of two main components: (a) the multimodal biometric sensor hardware and (b) the data acquisition software. The hardware part consists of four separate sub-systems namely an array microphone for the recording of speech (1), a front –facing USB web camera for the capturing of still and video face images (2), a USB optical fingerprint sensor (3) and a down-facing USB web-camera accompanied by two lighting units and a black board panel with six positioning pins for palm image acquisition (4).

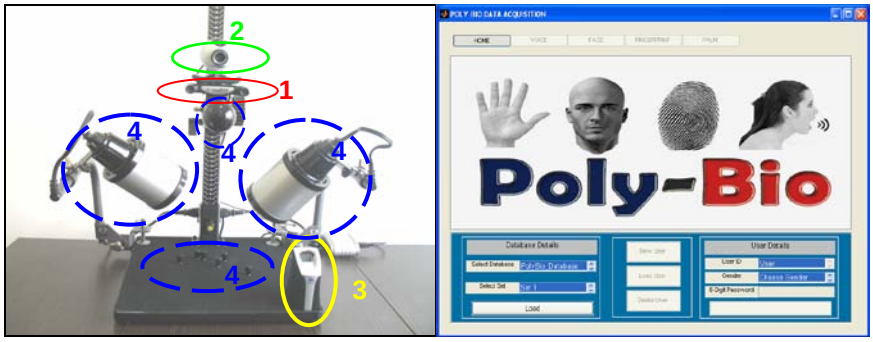
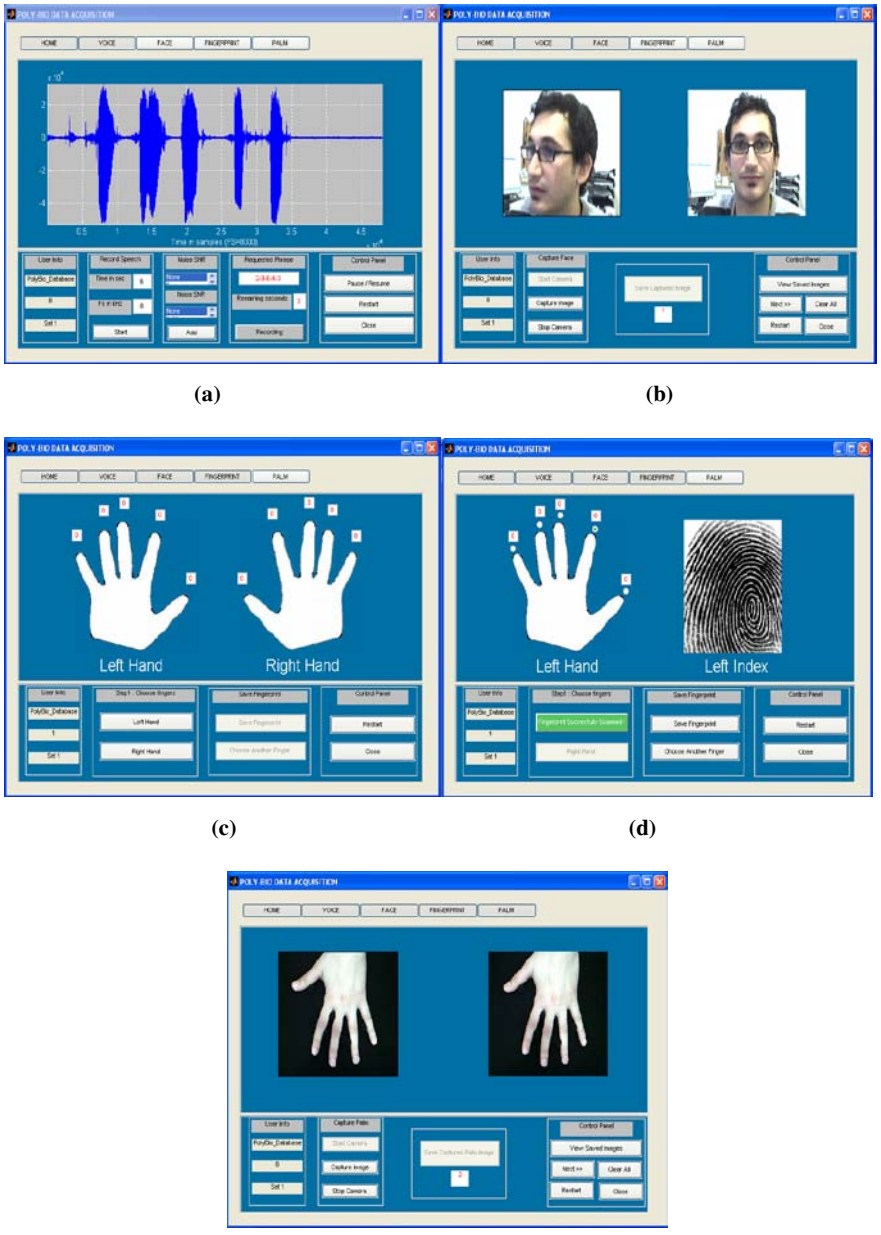


Fig. 1. (a) Hardware Component of Multibiometric Data Acquisition System. (b) Data Acquisition Software

The software part provides a user-friendly Graphical User Interface that allows the registration of every new user by choosing the person's gender and by assigning him or her with a five digit password. Furthermore, it can re-load any existing user for further capturing of the individual's biometric traits. Once a specific user has been selected or registered, the software provides four different interactive panels depicted in Fig. 2. (a) – (e) for the acquisition of the subject's biometric data. For each subject, the information collected for each of the modalities considered are given below through the following description:

Voice – Before the initiation of the recording procedure, the system provides the user with a choice on the sampling frequency of the recorded sample and its duration. The system prompts the test subject to pronounce a sequence of five digits in English.



(a) **(b)**

(c) **(d)**

(e)

Fig. 2. (a) Voice panel, (b) face panel, (c)-(d) fingerprint panels, (e) palm panel

This process is automated and the sequence of numbers appears in the white panel as shown in Fig. 2.(a). A clock counting backwards notifies the user when the recording begins. Once the sequence has been recorded, the speech wave appears on the axes shown at the top of Fig. 2.(a). The supervisor, sitting next to the test subject checks the recorded sequence through the use of a set of headsets connected to the array microphone to verify that no significant level of background noise has corrupted the recording. In case a sequence has to be repeated, the system provides a manual recording facility. This procedure is repeated twenty two times. Therefore, a total of twenty two five-digit sequences are collected for each individual in the database, one of which is his/her unique password that was used by the system for the user registration procedure and ten random sequences repeated on two times (Fig. 1.(b)).

Face –The process of collecting face images is completed with the aid of the interactive panel shown in Fig. 2.(b). Once the front facing camera of the system has been activated, a live streaming of the desired data appears on the left window. Once the supervisor finds the appropriate pose of the test subject, a snapshot is taken and is shown on the right hand window of Fig. 2.(b). If the still image is satisfactory, it is saved in the database. This procedure is repeated four times and a total of **four still images** are being collected for each individual. The system also captures a **live video** with duration of 20 seconds of each person so as to acquire more face angles, since the user is prompted by the system supervisor to turn his/her head left and right.

Fingerprint – Fig. 2.(c) and (d) depict the interfaces for selecting and capturing fingerprint images from the USB optical sensor. The panel shown in Fig. 2.(c) aids the individual to select the hand to be recorded (left or right). Once the hand has been selected, the fingerprint collection process is initiated. The supervisor chooses the finger to be scanned, thumb, index or middle and makes the appropriate selection in Fig. 2.(d). The user then prompts the subject to place the selected finger on the USB optical device and initiates the capturing of the fingerprint image. Once the captured image appears on the panel and is deemed satisfactory, the image is saved in the database. This process is repeated for four times for each finger and for both hands. Hence, the collected data are four images of the thumb, four of the index, four of the middle, four of the ring and four of the little finger for the left and right hand respectively, i.e. a total of forty scanned images for each individual.

Palm – The procedure of the palm image collection is similar to that of the face image collection and is completed with the aid of the panel shown in Fig. 2(e). The user is prompted by the supervisor to place his/her left hand facing downwards on the black board panel with the six positioning pins. The facing downwards camera is activated and the palm images are taken, which if they are considered by the system supervisor of good quality, they are stored in the database. A total of four palm images are collected for each individual.

Table 1 presents more information about the images acquired for face, palm and fingerprint modality. Other personal data that was acquired for all participants and stored independently from the database was gender, name, age and nationality. Moreover, donors wearing glasses had to remove them for half of the images of the face capture, so that facial samples of them without glasses -in case they wore contact lenses – would exist.

Table 1. Image Information

Modality	Height	Width	Format	Type
Face	240	320	Jpg	RGB
Palm	240	320	Jpg	RGB
Fingerprint	292	248	Jpg	Grayscale

Since biometric data is considered "personal data" defined as such by the corresponding regulation for the European requirements on the protection of individuals with regard to the processing and movement of personal data [6], all participants have willingly signed a consent agreement. This agreement ensured that these sensitive pieces of information should only be used and processed for the purposes of the current research project and that the movement of this material will be confined within the members of the participants of this project for further processing. Furthermore, all research outcomes that result from this data will be presented in an anonymous way.

3 Description of POLYBIO database

The panels shown in Fig. 2(b), (d) and (e) contain typical images for the face, fingerprint, and palm biometric traits respectively. The recorded speech utterances are shown in Fig. 2(a) only in terms of the speech waveform but there are saved in the database as a wav files.

Although a considerable effort was made to create a robust database through the use of the specialized hardware and software described in Section 2, and although a human supervisor was present at all times, the possibility of software and/or human errors was not completely eliminated. After initial acquisition of the biometric traits, all samples were verified by a human expert. The ones that were non-compliant with the acquisition protocol were discarded according to the following set of strict rules:

1 - All facial and palm samples should be four for each registered user. If any of these samples are missing the particular subject is rejected.

2 - The fingerprint images that should be acquired for each user are four scanned fingerprint images for all fingers of both hands (left and right). If any of these images is missing, the subject is rejected.

3 – The total number of speech utterances should be twenty-two five digit numbers pronounced in the English language. The above number results from the repetition two series of five-digit number utterances pronounced twice and the single utterance of five digits (also pronounced twice) that constitutes the individual password that was initially assigned to each participant during his /her enrollment to the database system. Errors in the pronunciation of the speech sequences can be corrected by the system supervisor during the acquisition procedure by manual re-entrance of the missing or incorrect sequence. Any future discovery of a missing or erroneous speech sample results in the discarding of the corresponding donor.

The following figure (Fig.3.) show the statistics of the biometric data and population acquired.

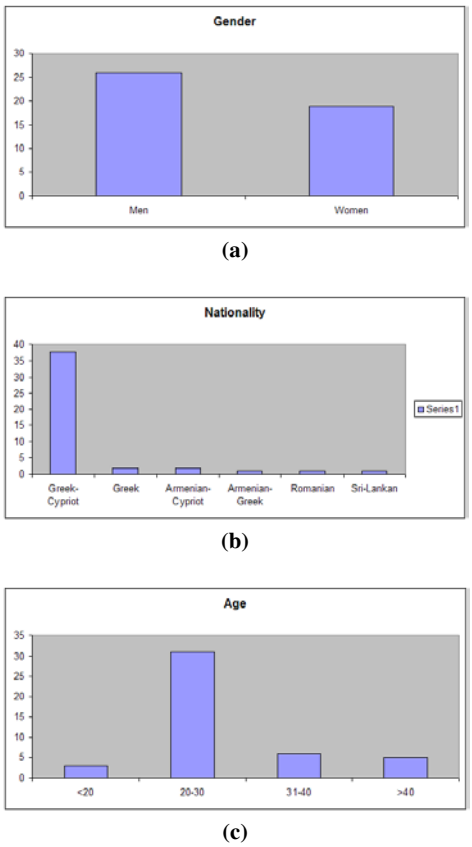


Fig. 3. Statistics of the biometric data, (a) gender, (b) nationality, (c) ages

4 Conclusions and Further Work

This paper presents a new multimodal database, containing biometric features of forty five individuals. The database consists of fingerprint images captured via an optical sensor, frontal and side views of still and video face images as well as the outside surface of the human palm from two web-camera sensors, and a series of voice utterances recorded with the use of a distant array microphone, resulting to a total of 2160 images and 990 pronounced speech utterances. The samples were collected with the use of a novel platform for biometric data acquisition and specific protocols were followed for the sound selection of all samples that were to be finally stored into the database. A variable number of test subjects were selected with a wide range of different characteristics in terms of age and nationality and pronunciation while the gender was kept almost in equal amounts. However, an increase in the number of test subjects with different characteristics is considered of high importance from the members of the project consortium, as it will add value to the diversity of the current database, making it an indispensible tool in applications where accurate user identification and recognition is required.

5 Acknowledgements

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